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The role of umbilical artery Doppler analysis in estimating perinatal morbidity and mortality in hypertensive pregnancy

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ABSTRACT

Aims: Uteroplacental (uterine artery systolic/diastolic (S/D) ratio) and fetal circulation changes (umbilical artery pulsatility Index (PI) value) can be evaluated non-invasively by using Doppler ultrasonography spectral analysis. The present study aimed to demonstrate how Doppler ultrasonography should be combined with classical well-being tests to detect perinatal morbidity and mortality in hypertensive pregnancy.

Methods: This prospective research was carried out with 88 pregnant women diagnosed with high-risk pregnancy and hypertension between April 1992 and May 1994. A non-stress test (NST) was performed in all cases, and fetal distress was evaluated by a biophysical profile (BP) and/or a contraction stress test (CST) subsequent to a non-reactive NST. Following the diagnosis of hypertension, longitudinal maternal (uterine artery) and fetal (umbilical artery) Doppler analyses were initiated at 7–10-day intervals. In the study, the Acuson 128 XP 10 device (Research project No. 515/080555592 was funded by the İstanbul University Research Fund) and a 3.5-5 MHz curvilinear probe were used. No Doppler pathology was considered solely in the timing of delivery.

Results: There was no case of perinatal loss, antepartum and intrapartum fetal distress, neonatal asphyxia, and oligohydramnios in the group with normal uterine and umbilical artery Doppler analyses. There was one case with umbilical artery Doppler flow pathology only, which was delivered by preterm cesarean section with the diagnosis of antepartum fetal distress. Fetus diagnosed to have a fetal growth restriction (FGR) and the findings of fetal distress, FGR, and cesarean delivery were concordant with the literature. There was also increased perinatal mortality (9.1%) among patients with pathological uterine artery Doppler and normal umbilical artery Doppler group, but there was no case of oligohydramnios in this group and the rate of neonatal asphyxia (5.min Apgar score <7) was 21.7%. The antepartum loss was 27%, the neonatal loss was 23.8%, and perinatal mortality was 44.8% in the group with pathological uterine and umbilical artery Doppler findings, and this group had all cases of oligohydramnios.

Conclusion: Overall, it seems reasonable to identify any pathologies with Doppler ultrasonography in hypertensive pregnant women in the early pregnancy and to follow them up with classical fetal antepartum surveillance tests at appropriate intervals related to their umbilical artery Doppler pathologies.

Keywords: Doppler ultrasonography, pregnancy, hypertension

INTRODUCTION

Hypertensive disorders, bleeding, and infections are considered significant causes of maternal death and, for example, accounted for 12% of maternal deaths between 1980 and 1985 in the USA.[1] Hypertension may be the most prevalent medical complication in pregnancy and is encountered in roughly 5-10% of pregnancies. Maternal or perinatal mortality related to hypertension in pregnancy is mostly preventable. Despite the early onset of the physiopathological findings of the disorder, clinical findings may appear after the 20th week of gestation.

In hypertensive pregnancy, fetal well-being is classically evaluated with fetal kick count, non-stress (NST) and contraction stress (CST) tests, amniotic fluid assessment, ultrasonographic fetal biometry, and biophysical profile (BP). These methods usually warns us for the fetuses with hypoxia and/or acidosis. Doppler ultrasonography velocimetry is a non-invasive method to measure the changes in the maternal and fetal circulation. A qualitative method, waveform (velocity) analysis, is utilized while evaluating blood flow with Doppler ultrasonography.[2] Qualitative Doppler analyses are performed

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based on systolic and diastolic flow velocities. Among these, the systolic/diastolic (S/D) ratio, pulsatility index (PI), and resistance index (RI) are adopted for Doppler flow analysis.[3-5]

Uterine arteries have a flow with a low diastolic component before pregnancy and they have a diastolic notch. The S/D ratio is lower than 2.6, and the notch should disappear after the 26th week of gestation. The opposite case may indicate that the mother and fetus are prone to undesirable outcomes.[6,7]

Umbilical circulation is completed at the 12th week of gestation.[6] Abdominal Doppler flow velocity assessments can be initiated in the 15th week since diastolic flow appears following this week. Depending on the formation of new vessels and the development of the autonomic system of the fetus, the deviations in the S/D ratio are higher until the 28-30th week of gestation. Changes in blood pressure occur as the fetus grows, and it is recommended to utilize a value of 3.0 as the cut-off S/D ratio limit for the umbilical artery following the 30th week.[6-8] In the literature, it was previously asserted that the outcomes of hypertensive pregnancies classified by Doppler findings would be better and that perinatal outcomes would mostly be related to umbilical artery Doppler findings.[9-12]

METHODS

This study was produced from the first author's specialization thesis in gynecology and obstetrics numbered 32785 and titled "The role of fetomaternal Doppler analysis in estimating perinatal morbidity and mortality in hypertensive pregnancy"

İstanbul University, İstanbul Faculty of Medicine Department of Obstetrics and Gynecology Academic Board granted ethical approval to this prospective cross-sectional study (Date: 01.04.1992, Thesis no: 32785). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki

We carried out this prospective study with 88 patients selected among hypertensive pregnancy cases followed up in the High-Risk Pregnancy Clinic or hospitalized in the wards between April 1992 and May 1994 in the İstanbul Faculty of Medicine, Department of Obstetrics and Gynecology, Division of Perinatology.

Patients with a systemic blood pressure of 140/90 mmHg and above after 20 weeks of gestation were described as cases with hypertensive pregnancy. Besides, the cases were evaluated as preeclampsia in the presence of (+) positive proteinuria qualitatively and 0.3 g/l or more proteinuria quantitatively in the 24-hour urine sample.

Immediately after the diagnosis, longitudinal maternal and fetal Doppler analyses were initiated at 7-10-day intervals. Doppler findings were presented for clinical use, but the Doppler pathologies was not considered solely in the timing of delivery. In the study, the Acuson 128 XP 10 device (Research project No. 515/080555592 was funded by the İstanbul University Research Fund) and a 3.5-5 MHz curvilinear probe were used. We then evaluated presence of diastolic notch in uterine arteries and uterine artery S/D ratios. The findings were considered pathological in cases with a mean S/D ratio of 2.6 and above in the uterine arteries and/or the presence of a diastolic notch.

Umbilical artery Doppler findings were evaluated using mean±2SD values by gestational week offered by Nicholaides et al. (1994, FMF, unpublished data); the presence of absent end-diastolic and reversed flows were visually evaluated. The Doppler filter was kept to a minimum in the absence of end-diastolic flow.

With the help of uterine artery and umbilical artery Doppler findings, we sought perinatal mortality and timing, antepartum and intrapartum fetal distress and neonatal asphyxia rate, oligohydramnios, neonatal growth restriction (NGR), preterm birth, NST non-reactivity (in the whole group and above 30 weeks), low BP score (< 8), CST positivity, cesarean delivery rate and cesarean section for fetal distress rate, newborn intensive care rate and duration, delivery gestational week and weight, maternal mean arterial blood pressure, and presence of preeclampsia.

Statistical Analysis

We performed an independent samples t-test and Fisher's exact test to compare the Doppler findings and the mentioned parameters between the groups.

RESULTS

As shown in **Table 1**, we sought the relationship between the mentioned parameters and PI values in umbilical artery Doppler findings - categorized as normal (< +2 SD) and pathological (> +2 SD) - and compared them with the results of the antepartum fetal assessment tests.

Table 1: Comparison of Maternal and Fetal Outcomes Between the Groups with Normal and Pathological Umbilical Artery PI Values

	Normal Umbilical Artery PI Value		Pathological Umbilical Artery PI Value		
	(n=51)	(%)	(n=37)	(%)	
Antepartum fetal loss	1/51	1.9%	8/37	21.6%	*
Neonatal loss	2/50	4%	7/29	24.1%	*
Perinatal mortality	3/51	5.8%	15/37	40.5%	**
Intrapartum and antepartum fetal distress	12/51	23.5%	28/37	75.7%	**
Neonatal asphyxia	5/50	10%	4/29	13.8%	ǿ
Oligohydramnios	0/51	-	9/37	24.3%	**
Neonatal Growth Retardation	10/50	20%	8/29	62.1%	**
Preeclampsia	36/51	70.6%	33/37	89.2%	*
Preterm birth	28/50	56%	26/29	89.6%	*
NST non-reactivity rate	12/51	23.5%	31/37	83.8%	**
NST non-reactivity rate at > 30th week	8/46	17.4%	20/25	80%	**
BP score < 8	4/15	26.7%	11/19	57.9%	ǿ
CST positivity rate	3/7	42.8%	8/11	72.7%	ǿ
Cesarean section (live births}	27/50	54%	25/29	86.2%	*
Cesarean section for fetal distress	8/50	16%	17/29	89.5%	**
Newborn intensive care rate	28/50	56%	27/29	93.1%	**
Newborn care duration (mean)	14.8±16.7 days		19.7±17.6 days		ǿ
Gestational week at delivery (mean)	35.9±3.5 weeks		32.6±3.2 weeks		**
Birth weight (mean)	2346.3±826.7 gr		1418.6±637.7 gr		**
Mean arterial blood pressure (mean)	121.1±13.7 mmHg		118.7±14.4 mmHg		ǿ

* p < 0.05, ** p < 0.001, ǿ: insignificant

The findings revealed significantly increased antepartum fetal loss, neonatal loss, perinatal mortality, and antepartum and intrapartum fetal distress in the cases with pathological umbilical artery Doppler results. Despite no patient with oligohydramnios in the group with normal umbilical artery Doppler indices, it was found to be significantly increased in the other group. There were significantly more subjects with neonatal GR, preeclampsia, and preterm delivery in the group with pathological umbilical artery Doppler findings. Moreover, NST non-reactivity in all gestational weeks and above 30 weeks, low BP score (< 8), CST positivity, cesarean section rate, and cesarean section for fetal distress were found to be significantly increased in the group with pathological umbilical artery Doppler pathological indices. Regarding neonatal care rate and duration, the increase in only the cases requiring neonatal care was significant in the group with pathological umbilical artery Doppler findings. The mean gestational week and birth weight were found to be 35.9±3.5 weeks and 2346.3±826.7 g, respectively, among the cases with normal umbilical artery Doppler findings. These values were discovered to be 32.6±3.2 weeks and 1418.6±637.7 g, respectively, in the cases with pathological umbilical artery Doppler indices. The differences between the groups by these parameters were significant.

After examining the cases in two groups (normal and pathological) by their umbilical artery Doppler PI values (>+2 SD and <+2 SD), those with pathological findings were further divided as absent end-diastolic flow and reverse end-diastolic flow in the umbilical artery, described as severe Doppler pathologies in the literature. Accordingly, among 37 patients with pathological umbilical artery Doppler findings (PI value > +2 SD), we separately evaluated 20 patients with a reduction in end-diastolic flow, 12 cases with absent end-diastolic flow, and 5 cases with a reverse end-diastolic flow.

The antepartum fetal loss was significantly higher in the cases with a reverse end-diastolic flow, while the neonatal loss rate was statistically significant among the patients with pathological PI with diminished end-diastolic flow group. The perinatal mortality was found to be 5.8% in umbilical PI normal hypertensive cases, 40% in those with diminished end-diastolic flow, 25% in the cases with an absent end-diastolic flow, and 80% in those with a reverse end-diastolic flow. Antepartum and intrapartum fetal distress was significantly increased in all subgroups of the pathological cases. In addition, oligohydramnios was significantly higher in the cases with absent end-diastolic flow and reverse end-diastolic flow groups.

The severity of the Doppler pathology significantly affected the number of patients with neonatal GR. The difference between pathological cases with an end-diastolic flow and those with a normal umbilical flow was significant for preeclampsia ($p < 0.05$). Besides, NST non-reactivity rate was discovered to be significantly increased in all cases with pathological umbilical artery Doppler findings. However, we could not conclude significant differences between the groups by low BP score and CST positivity.

The cases with normal and pathological Doppler findings significantly differed by cesarean section rate and cesarean section for fetal distress. For example, the mean rates of cesarean section and cesarean section for fetal distress were found to be 90% and 70% in the cases with an absent end-diastolic flow loss, respectively. These values became 100% and 50% in the cases with a reverse end-diastolic flow.

We found that the rate of newborns requiring neonatal intensive care and the mean duration of care increased by the severity of Doppler pathology. Besides, the mean gestational week at delivery and birth weight significantly decreased by Doppler pathology. However, we could not find a relationship between the mean arterial blood pressure and the degree of umbilical artery Doppler pathology.

Table 2: Perinatal Outcomes of the Cases with Normal Umbilical Artery Doppler PI Values and the Patients with pathological PI with a diastolic flow, absent end-diastolic Flow, and Reverse End-diastolic Flow.

	Normal Umbilical Artery PI		Pathologic Umbilical artery PI with a diastolic flow			Absent End-diastolic flow			Reverse end-diastolic flow		
	(n = 51)	(%)	(n = 20)	(%)		(n = 12)	(%)		(n = 5)	(%)	
Antepartum fetal loss	1/51	1.9%	3/20	15%	ǿ	2/12	16.6%	ǿ	3/5	60%	*
Neonatal loss	2/50	4%	5/17	29.4%	*	1/10	10%	ǿ	1/2	50%	ǿ
Perinatal mortality	3/51	5.8%	8/20	40%	*	3/12	25%	ǿ	4/5	80%	**
Intrapartum and antepartum fetal distress	12/51	23.5%	14/20	70%	**	10/12	83.3%	**	4/5	80%	*
Neonatal asphyxia	5/50	10%	4/17	20.5%	ǿ	0/10	-	ǿ	0/2	-	ǿ
Oligohydramnios	0/51	-	1/20	5%	ǿ	4/12	33.3%	**	3/5	60%	**
Neonatal Growth Retardation	10/50	20%	8/17	47.05%	*	6/10	60%	*	2/2	100%	*
Preeclampsia	36/51	70.5%	19/20	95%	*	10/12	83.3%	ǿ	4/5	80%	ǿ
Preterm birth	28/50	56%	14/17	82.3%	*	10/10	100%	*	5/5	100%	ǿ
NST non-reactivity rate	12/51	23.5%	15/20	75%	**	12/12	100%	**	4/5	80%	*
NST non-reactivity rate at > 30th week	8/46	17.3%	9/13	69.6%	**	9/9	100%	**	2/3	66.6%	ǿ
BP score < 8	4/15	26.6%	7/11	63.6%	ǿ	3/5	60%	ǿ	1/3	33.3%	ǿ
CST positivity rate	3/7	42.8%	4/6	66.6%	ǿ	3/4	75%	ǿ	1/1	100%	ǿ
Cesarean section (live births}	27/50	54%	14/17	82.3%	*	9/10	90%	*	2/2	100%	ǿ
Cesarean section for fetal distress	8/50	16%	9/17	52.9%	*	7/10	70%	*	1/2	50%	ǿ
Newborn care rate	28/50	56%	15/17	88.2%	*	10/10	100%	*	2/2	100%	ǿ
Newborn care duration (mean)	14.8±16.7 days		15.3±12.9 days		ǿ	24.7±19.7 days		ǿ	28.5±38.9 days		ǿ
Gestational week at delivery (mean)	35.9±3.5 weeks		32.9±3.7 weeks		*	32.6±3.7 weeks		*	31.2±1.4 weeks		*
Birth weight (mean)	2346.3±826.7 gr		1588±781.9 gr		**	1325 ±314.1 gr		**	966 ±244.5 gr		**
Mean arterial blood pressure (mean)	121.1±13.7 mmHg		121.4± 16.1 mmHg		ǿ	117.5±12.9 mmHg		ǿ	111±7.7mmHg		ǿ

* $p < 0.05$, ** $p < 0.001$, ǿ: insignificant

DISCUSSION

We observed that all of the perinatal mortality (25.8%) in hypertensive pregnancies were the cases with pathological uterine artery Doppler findings. While the mean birth weight and gestational week were significantly decreased, the prevalence of antepartum and intrapartum fetal distress was significantly increased in these cases. Accordingly, the rates of cesarean section for fetal distress, preterm delivery, and neonatal asphyxia were significantly increased. Moreover, we concluded significant increases in preeclampsia, NGR, and neonatal care among the cases with pathological uterine artery Doppler findings. Our findings overlap with those of Campbell[13] and Fleischer.[14]

While some authors utilized the S/D ratio, some others preferred the umbilical artery PI value in the evaluation of umbilical artery Doppler indices. We found that antepartum and neonatal mortality significantly increased in the cases with umbilical artery PI value > +2 SD by gestational week. Moreover, perinatal mortality was 40.5%, and the difference was significant. Berkowitz et al.[15] reported that poor perinatal outcomes become more prevalent with abnormal Umbilical artery Doppler findings. Similarly, it was previously reported that in the group of growth retarded fetuses Doppler velocimetry help us to early and accurately diagnose the ones who would develop antepartum fetal distress.[16] In different studies, it was documented that almost all FGR-leading mortality and almost all cases requiring neonatal care were in fetuses with abnormal Doppler findings.[17,18] These findings seem to support our results.

All of the oligohydramnios cases were in the group with pathological umbilical artery Doppler findings. A study on oligohydramnios cases due to uteroplacental perfusion disorder demonstrated an increase in renal artery Doppler indices and, therefore, decreased flow in fetuses with oligohydramnios, which was then attributed to reduced umbilical artery flow in fetuses with growth restriction.[19] In our study, the prevalence of oligohydramnios significantly increased as the umbilical artery flow decreased. Similarly, Reed et al.[20] reported the prevalence of oligohydramnios as 57% in cases with no or reversed end-diastolic flow.

The idea of fetal preeclampsia can be supported by the relationship between Trisomy and preeclampsia.[21] Despite pregnancy-induced hypertension and normal uterine artery Doppler findings in the mother, the fetus may have abnormal umbilical artery Doppler findings.[22] In our study, postpartum Trisomy[21] was diagnosed in one case among 17 patients with an end-diastolic flow loss or reversed end-diastolic flow (5.8%). The presence of an absent end-diastolic flow or a reverse flow and the prevalence of Trisomy (13, 18, or 21) were previously reported to be between 12.6% - 17%.[11,12,18,20,23] Suspicion of abnormal karyotype increases in the third trimester, particularly in the absence of a maternal hypertension clinic or in the presence of unexplained FGR.[17] In cases without an absent umbilical artery diastolic flow or with a reverse flow, emergency delivery should never be indicated, but instead, daily fetal cardiotocographic monitoring is recommended upon such a Doppler finding.[24]

CONCLUSION

No clinical data, including maternal blood pressure, can be helpful enough to assess the severity of the condition in hypertensive pregnancy cases. The desire to regulate the course of treatment and identify a protocol for fetal evaluation often brings problems such as redundant fetal evaluation tests and hospitalization. In modern obstetrics, identifying maternal and fetal hemodynamic changes in hypertensive pregnancy cases is ensured with the use of Doppler ultrasonography. Its routine clinical deployment also provides information about the existing pathology and the etiology of hypertension in pregnancy.

Doppler ultrasonography is a convenient-to-use, non-invasive, and fast method for selecting cases with hypertensive pregnancy into specific risk groups and determining the prevalence of fetal evaluation tests. Since the morbidity of cases with normal uterine and umbilical artery Doppler findings similiar with the general population, it is deemed appropriate to perform maternal and fetal evaluations at weekly intervals. On the other hand, abnormal umbilical artery Doppler findings allow for predicting placental blood flow and resistance in the placental vascular bed. A reduced, absent, or reversed end-diastolic flow enables the obstetrician to perform more frequent, even daily fetal follow-ups and wait for the appropriate fetal maturity, which would mitigate prematurity-related perinatal complications. In a nutshell, umbilical artery Doppler is a valuable method in the management of high-risk pregnancies and may contribute to fetal outcomes by helping decide on the time of delivery.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of İstanbul University İstanbul Faculty of Medicine Department of Obstetrics and Gynecology Academic Board (Date: 01.04.1992, Thesis no: 32785).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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